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Macrozoobenthic community of Fuxian Lake, the deepest lake of southwest China

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Abstract

Located in the Yunnan–Guizhou Plateau in southwest China, Fuxian Lake covers an area of 211 km^2, with maximum depth of 155 m. It is known to have a unique fauna, including 14 described endemic species. In order to describe the zoobenthic community of the lake more completely, the present study was conducted from August 2002 to August 2003. Altogether 62 benthic taxa, including 22 oligochaetes, 21 molluscs and 18 insects were identified, of which the dominant taxa belonged to *Potamothrix*, *Procladius* and *Paraprososthenia*. The standing stocks of benthos were much higher in the littoral (824 ind/m^2 in density, 3.72 g/m^2 in biomass) than in the profundal region (23 ind/m^2 in density, 0.10 g/m^2 in biomass). Species richness was greatest in summer and standing stocks were larger in spring and summer than in other seasons. Analyses of functional feeding groups indicated that collector-gatherers and scrapers were predominant in entire lake. Stepwise multiple regression analysis demonstrated that the water depth is the most important factor affecting the distribution of macrozoobenthos.

Keywords: Macrozoobenthos; Taxonomic composition; Standing crop; Functional feeding group; Fuxian Lake

Introduction

Macrozoobenthos plays an important role in linking detrital deposits and higher trophic levels in lake ecosystems (Brinkhurst, 1974; Hanson and Peters, 1984). This group has been extensively studied in Euro-American deep lakes (Ambrosetti and Barbanti, 2001; Barton, 2004; Dermott and Kerec, 1997; Grigorovich et al., 2003; Kravtsova et al., 2004; Lozano et al., 2001; Martin et al., 1999; Nalepa et al., 2003; Nocentini et al., 2001; Snimschikova and Akinshina, 1994), and Chinese shallow lakes (Chen et al., 1980; Jiang et al., 2006; Liang and Liu, 1995; Xu et al., 2003), but little attention has been paid to Chinese deep lakes so far.

Located in the Yunnan–Guizhou Plateau in southwest China, Fuxian Lake (E 102°49′–57′, N 24°17′–37′) is the deepest lake in the above area. This tectonic lake is known to have a unique fauna, including 14 endemic species described to date (Cui and Wang, 2005; Sket, 2000; Yang and Chen, 1995). However, previous works on macrozoobenthos in this lake were chiefly concentrated on these uncommon findings (Liu et al., 1980; Sket, 2000; Wang, 1988); a study covering entire benthic community is still lacking.

In 2002–2003, an investigation of macrobenthos in Fuxian Lake was carried out as a part of a project on the biological limnology of Plateau Lakes. The results,

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including community structure, characteristics of the macrofauna, seasonal changes and environmental parameters, are dealt with in the present paper. A new endemic species found during the work was described previously (Cui and Wang, 2005).

Study area and methods

Formed by faulting in the late Pliocene (3.0–4.0 Ma), Fuxian Lake is one of the characteristic tectonic lakes of Yunnan–Guizhou Plateau. It covers an area of 211 km^2 at a water level of 1721 m a.s.l., with maximum length of 31.5 km, and maximum width of 11.5 km. The maximum depth is 155 m and the average depth is 87 m. Shoreline development (D_L) equals 1.72 (Fig. 1). The climate is warm and wet. Annual mean air temperature around lake area is 15.6 °C. Mean annual precipitation is 942.4 mm (84% occurring in May–October), and mean evaporation is 1400 mm. The lake receives surface runoff from the catchment (1044.6 km^2) through many streamlets. It also receives water from a eutrophic lake in the south and discharges into Nanpanjiang River through Haikou River in the east. Annual mean temperatures of lake water in upper and bottom layers are 19.1 ± 1.2 °C (SE) and

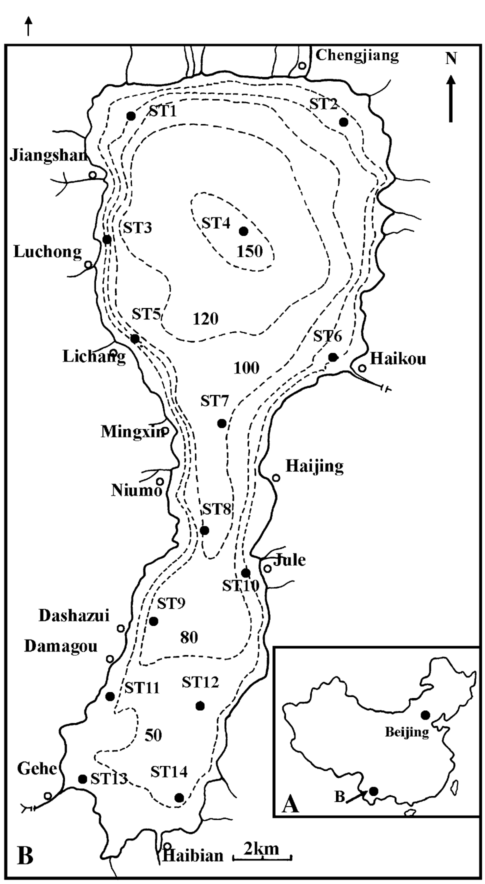

Fig. 1. Sampling stations in Fuxian Lake (B) and its location in China (A). Dashed lines show isobaths.

14.2 ± 0.1 °C, respectively. Mean thermocline (H) is located at a depth of 22.4 m. Dissolved oxygen in water above 50 m is 7 mg L^{-1} and gradually decreases with increasing depth to 0.8 mg L^{-1} at the bottom. The lake is oligo-mesotrophic. Aquatic macrophytes cover less than 0.1% of the bottom. Lake sediments are mainly clay and sand clay (Nanjing Institute of Geography and Limnology, 1990).

Fourteen sampling stations (ST) were set up in the lake (Fig. 1). They were grouped by depth into three zones: Zone I (depth (Z) < 50 m, including ST3, 11 and 13), Zone II (Z = 50–100 m, including ST1, 2, 6, 8, 9, 10, 12 and 14); and Zone III (Z > 100 m, including ST4, 5 and 7). Physico-chemical properties of the three zones are summarized in Table 1.

Sampling was carried out bimonthly from August 2002 to August 2003. Benthic samples were collected by a weighted Peterson sampler (0.08 m^2), and cleaned gently with a 250 μm sieve. Animals were sorted under a dissecting microscope and preserved in 10% formalin. All specimens were identified to species or genus level whenever possible, based on the keys in Brinkhurst and Jamieson (1971), Epler (2001), Liu et al., (1979), Morse et al., (1994), Sperber (1948) and Wang (2002).

Animals were mainly identified to species or genus. All taxa were assigned to functional feeding groups (shredders, collector-gatherers, collector-filterers, scrapers and predators) according to Morse et al., (1994) and Liang and Wang (1999), or by direct examination of their gut contents. When a taxon has several possible feeding activities, its functional designations were equally proportioned. Wet biomass of larger animals was determined with an electronic weigher after being blotted (molluscan shells retained), while that of smaller worms was calculated from length (L)–weight (W) relationship formula ($W = aL^b$; see Yan, 1998).

Statistic 6.0 was used for one-way ANOVA analyses. Standing stocks were compared among zones using Unequal N HSD Test after one-way ANOVA.

Jaccard coefficient (S_j) was applied to compare the compositions of benthic communities between Fuxian Lake and other lakes (Wu and Liang, 1999):

$$S_j = \frac{c}{(a + b - c)},$$

where a is the number of species in community A, b is the number of species in community B, and c is the number of species common to both communities.

Results

Community structure

Species composition

Altogether 62 taxa belonging to 13 families and 46 genera were identified from quantitative samples.

Table 1. Physico-chemical parameters of sampling zones in Fuxian Lake (mean ± SE)

Parameters	Zone I	Zone II	Zone III	Entire lake
Water depth (m)	37.1 ± 4.3	83.0 ± 4.1	122.8 ± 12.7	81.8 ± 8.5
Secchi depth (m)	6.7 ± 0.2	7.1 ± 0.2	7.4 ± 0.1	7.1 ± 0.1
Temperature (°C)				
Upper	19.6 ± 2.0	19.4 ± 1.8	18.9 ± 0.8	19.1 ± 1.2
Bottom	17.2 ± 0.7	14.6 ± 0.2	14.4 ± 0.1	14.2 ± 0.1
pH	8.9 ± 0.05	8.8 ± 0.03	8.7 ± 0.20	8.8 ± 0.04
Conductivity (μS/cm)	29.8 ± 0.20	30.0 ± 0.28	29.1 ± 0.50	29.2 ± 0.21
Chlorophyll *a* (μg/L)	2.4 ± 0.24	2.1 ± 0.05	2.0 ± 0.11	2.2 ± 0.06
Total nitrogen (mg/L)	0.204 ± 0.003	0.199 ± 0.005	0.188 ± 0.001	0.198 ± 0.003
Total phosphorus (mg/L)	0.022 ± 0.000	0.021 ± 0.000	0.022 ± 0.001	0.021 ± 0.000

Among them were 22 species of oligochaetes, 21 species of molluscs and 18 species of aquatic insects (Table 2). Although the numbers of species were the same in Zone I and Zone II (47), the species composition was different, i.e. more molluscan species occurred in the former region. Only nine species were found in Zone III.

Among oligochaete species, *Potamothrix scleropenis* is endemic (Cui and Wang, 2005), and the specific identities of another six, *Potamothrix* sp.1, *Potamothrix* sp.2, *Potamothrix* sp.3, Tubificinae gen. sp.1, Tubificinae gen. sp.2, and Tubificinae (?) gen. sp., are still in doubt. Their taxonomic position and geographic distribution need further study.

Body size

Mean body length of oligochaetes was 10.2 ± 0.85 mm (SE), mean shell height of gastropods was 5.2 ± 0.22 mm, mean shell length of bivalve was 3.6 ± 1.05 mm, and mean body length of insect larvae was 5.3 ± 0.26 mm. The body sizes of macrozoobenthos were not significantly different among the three zones.

Densities of invertebrates

The average standing stock of zoobenthos in the lake was 327 ± 106 ind/m^2 and 1.7 ± 0.64 g/m^2 in wet biomass. Insects and molluscs were the most abundant organisms accounting for 44.6% of density and 82.2% of biomass, respectively (Fig. 2). Total invertebrate density declined with increasing depth.

Predominant species

Quantitative aspects of taxa are given in Table 2. According to the abundance, *Procladius* and *Paraprososthenia* were predominant in Zone I where they contributed 39.6% and 25.5% of density and 13.4% and 35.5% in biomass, respectively. *Procladius* and *Paraprososthenia* were also predominant in Zone II, but their relative abundances were different, being 25.6% and 21.5% in density and 4.8% and 28.2% in biomass. The predominant forms in Zone III were *Potamothrix* and *Procladius*, comprising 49.6% and 29.8% in density, and 49.4% and 13.3% in biomass, respectively.

Functional structure

The relative abundances of five functional feeding groups are shown in Fig. 3. Collector-gatherers and scrapers were predominant in entire lake, respectively comprising 48.7% and 30.6% in number of species, 44.8% and 32.1% in density, and 12.2% and 52.9% in biomass. Zone I had more scrapers than collector-filterers or predators as compared with that in Zone II, although the total species numbers in both zones were equal. The relative abundance of collector-gatherers in Zone III was higher than that in other zones, but the absolute values of all groups in this zone were very low.

Seasonal dynamics

Fig. 4 shows the seasonal changes in number of taxa and standing stock. It shows that the season changes of abundance in entire lakes were similar than those of littoral zone. And it demonstrates that the benthic fauna was richer in summer, e.g., 35 species were observed in June, but only 15 species in October. However, higher density and greater biomass were observed in spring and summer, with the maximum density (803 ind/m^2) and biomass (2.64 g/m^2) in April. The minimum density (66 ind/m^2) and biomass (0.11 g/m^2) were observed in October.

Discussion

Ecological role of benthos in Fuxian Lake

By multiplying biomass and P/B ratio (Oligochaetes: 6.4 ± 1.46; Molluscs: 2.8 ± 0.79; Insects: 4.5 ± 0.44) reported by Wang et al., (2005), the annual production of

Table 2. Density (D; ind/m^2), biomass (B; g/m^2; wet weight) and percentage of taxa in Fuxian Lake

Taxa	Functional group[b]	Zone I				Zone II				Zone III			
		D	%	*B*	%	*D*	%	*B*	%	*D*	%	*B*	%
Nematoda		–	–	–	–	1	0.1	–	–	–	–	–	–
Annelida													
Oligochaeta													
Naididae													
Allonais pectinate (Stephenson, 1910)	sc	–	–	–	–	1	0.1	0.000	0.0	–	–	–	–
Nais communis (Piguet, 1906)	sc	1	0.1	0.000	0.0	–	–	–	–	–	–	–	–
Dero dorsalis (Ferroniere, 1899)	cg	–	–	–	–	1	0.1	–	–	–	–	–	–
D. digitata (Müller, 1773)	cg	1	0.1	0.000	0.0	1	0.1	0.000	0.0	–	–	–	–
Tubificidae													
Branchiura sowerbyi (Beddard, 1892)	cg	3	0.4	0.023	0.6	1	0.1	0.009	0.5	–	–	–	–
Limnodrilus hoffmeisteri (Claparede, 1862)	cg	**27**	**3.2**	**0.051**	**1.4**	**5**	**2.2**	**0.017**	**1.1**	–	–	–	–
L. grandisetosus (Nomura, 1932)	cg	2	0.3	0.001	0.0	–	–	–	–	–	–	–	–
L. udekemianus (Claparede, 1862)	cg	2	0.2	0.001	0.0	1	0.2	0.001	0.0	–	–	–	–
Tubifex tubifex (Müller, 1774)	cg	**27**	**3.2**	0.020	0.5	**9**	**3.9**	0.008	0.5	–	–	–	–
Ilyodrilus templetoni (Southern, 1909)	cg	**26**	**3.1**	0.014	0.4	**8**	**3.5**	0.012	0.7				
Aulodrilus limnobius (Bretscher, 1899)	cg	6	0.7	0.005	0.1	**6**	**2.4**	0.007	0.5	–	–	–	–
A. pluriseta (Piguet, 1906)	cg	**9**	**1.1**	0.004	0.1	1	0.4	0.001	0.1	–	–	–	–
A. japonicus (Yamaguchi, 1953)	cg	**8**	**1.0**	0.004	0.1	1	0.1	0.000	0.0	–	–	–	–
A. pectinatus (Aiyer, 1928)	cg	1	0.1	0.000	–	–	–	–	–	–	–	–	–
Potamothrix bedoti (Piguet, 1913)	cg	2	0.3	0.003	0.1	1	0.4	0.003	0.2	**1**	**3.3**	**0.002**	**2.2**
P. scleropenis (Cui et Wang, 2005)[a]	cg	–	–	–	–	1	0.1	0.001	0.1	–	–	–	–
Potamothrix sp. 1[a]	cg	8	0.9	0.004	0.1	**3**	**1.4**	0.005	0.3	**1**	**3.3**	**0.002**	**2.2**
Potamothrix sp. 2[a]	cg	**11**	**1.3**	0.015	0.4	**10**	**4.4**	**0.030**	**1.9**	**8**	**36.4**	**0.044**	**42.7**
Potamothrix sp. 3[a]	cg	**9**	**1.1**	**0.013**	**0.3**	**6**	**2.4**	**0.018**	**1.1**	**2**	**9.9**	**0.005**	**4.5**
Tubificinae gen. sp. 1[a]	cg	4	0.5	0.006	0.2	1	0.4	0.003	0.2	**2**	**6.6**	**0.004**	**3.9**
Tubificinae gen. sp. 2[a]	cg	**28**	**3.4**	0.017	0.4	**12**	**5.1**	0.013	0.8	–	–	–	–
Tubificinae (?) gen. sp.[a]	cg	–	–	–	–	1	0.1	–	–	–	–	–	–
Mollusca													
Gastropoda													
Bithyniidae													
Bithynia fuchsiana (Moellendorff, 1888)	sc	2	0.3	**0.132**	**3.5**	–	–	–	–	–	–	–	–
Planorbidae													
Gyraulus sp.	sc	**9**	**1.1**	**0.012**	**0.3**								
Hippeutis sp.	sc	5	0.6	0.027	0.7								
Hydrobiidae													
Hubendickia sp. 1	sc	1	0.1	0.020	0.5	**3**	**1.2**	**0.124**	**7.9**	–	–	–	–
Hubendickia sp. 2	sc	2	0.3	**0.041**	**1.1**	**4**	**1.7**	**0.133**	**8.5**	**1**	**3.3**	**0.028**	**26.8**
Hubendickia sp. 3	sc	–	–	–	–	1	0.3	**0.022**	**1.4**	–	–	–	–
Paladilhia yunnanensis	sc	2	0.3	0.004	0.1	–	–	–	–	–	–	–	–
Paladilhia sp.		2	0.3	0.004	0.1	–	–	–	–	–	–	–	–
Paraprososthenia taylori (Jordan, 1942)	sc	**45**	**5.4**	**0.329**	**8.8**	**23**	**10.2**	**0.181**	**11.5**	–	–	–	–
P. costata	sc	**72**	**8.7**	**0.493**	**13.2**	2	0.8	0.015	0.9	–	–	–	–
P. kunmingensis	sc	7	0.8	**0.051**	**1.4**	**17**	**7.4**	**0.126**	**8.1**	**1**	**3.3**	**0.004**	**4.1**

Table 2. (*continued*)

Taxa	Functional group[b]	Zone I				Zone II				Zone III			
		D	%	*B*	%	*D*	%	*B*	%	*D*	%	*B*	%
Paraprososthenia sp.	sc	**88**	**10.6**	**0.450**	**12.1**	**7**	**3.1**	**0.122**	**7.7**	–	–	–	–
Tricula costat	sc	1	0.1	0.010	0.3	1	0.2	0.002	0.2	–	–	–	–
Lithoglyphopsis grandis	sc	2	0.2	0.029	0.8	–	–	–	–	–	–	–	–
Lacunopsis sp.	sc	–	–	–	–	2	0.7	**0.035**	**2.2**	–	–	–	–
Thiaridae													
Melanoides tuberculata	sc	1	0.1	0.009	0.2	1	0.3	**0.037**	**2.4**	–	–	–	–
Lymmaeidae													
Radix sp.	sc	6	0.7	**0.052**	**1.4**	–	–	–	–	–	–	–	–
Stenothyridae													
Stenothyra glabra	sc	**21**	**2.5**	**0.390**	**10.5**	1	0.3	0.009	0.5	–	–	–	–
Ancylidae													
Ferrissia sp.	sc	–	–	–	–	1	0.1	–	–	–	–	–	–
Bivalvia													
Cobiculidae													
Corbicula fluminea	sf	**17**	**2.0**	**0.921**	**24.7**	**3**	**1.1**	**0.537**	**34.2**	–	–	–	–
Mytilidae													
Mytilidae gen. sp.	sf	–	–	–	–	2	0.7	–	–	–	–	–	–
Insecta													
Chironomidae													
Procladius sp.	pr, cg	**327**	**39.6**	**0.500**	**13.4**	**59**	**25.6**	**0.075**	**4.8**	**7**	**29.8**	**0.014**	**13.3**
Chironomus plumosus	sh, cg	**8**	**1.0**	**0.037**	**1.0**	–	–	–	–	–	–	–	–
Chironomus sp.	sh, cg	2	0.3	0.001	0.0	0	0.1	0.000	0.0	–	–	–	–
Clinotanypus sp.	pr	–	–	–	–	1	0.2	0.001	0.1	–	–	–	–
Crytotendipes sp.	pr	–	–	–	–	0	0.1	0.000	0.0	–	–	–	–
Djalmabatista sp.	pr, cg	2	0.3	0.002	0.0	2	0.8	0.002	0.1	–	–	–	–
Dicrotendipes sp.	cg, cf, sc	1	0.1	0.001	0.0	–	–	–	–	–	–	–	–
Einfeldia sp.	cg	2	0.2	0.002	0.0	1	0.2	0.000	0.0	–	–	–	–
Kiefferulus sp.	cg	2	0.2	0.004	0.1	–	–	–	–	–	–	–	–
Larsia sp.	pr	–	–	–	–	0	0.1	0.000	0.0	–	–	–	–
Macropelopia sp.	pr	1	0.1	0.001	0.0	1	0.4	0.001	0.1	–	–	–	–
Paracladius sp.	cg	–	–	–	–	0	0.1	0.000	0.0	–	–	–	–
Paralauterborniella sp.	cg	–	–	–	–	1	0.4	0.000	0.0	–	–	–	–
Polypedilum sp.	sh, cg, pr	4	0.5	0.009	0.2	0	0.1	0.000	0.0	–	–	–	–
Paratanytarsus sp.	cf, cg, sc	–	–	–	–	0	0.1	0.000	0.0	–	–	–	–
Rheotanytarsus sp.	cf	1	0.1	0.001	0.0	1	0.2	0.000	0.0	–	–	–	–
Tanytarsus limneticus (Sublette, 1964)	cg, cf, sc	**21**	**2.5**	0.011	0.3	**35**	**15.4**	**0.019**	**1.2**	**1**	**3.3**	0.000	0.1
Zavrelimyia sp.	cg	–	–	–	–	0	0.1	0.000	0.0	–	–	–	–
Total		825	100.0	3.724	100.0	229	100.0	1.570	100.0	23	99.9	0.104	100.0

Bold letters denote relative abundance >1% and (–) denotes no occurrence.

[a]Endemic species.

[b]sh, shredder; cg, collector-gatherer; cf, collector-filterer; sc, scraper; pr, predator.

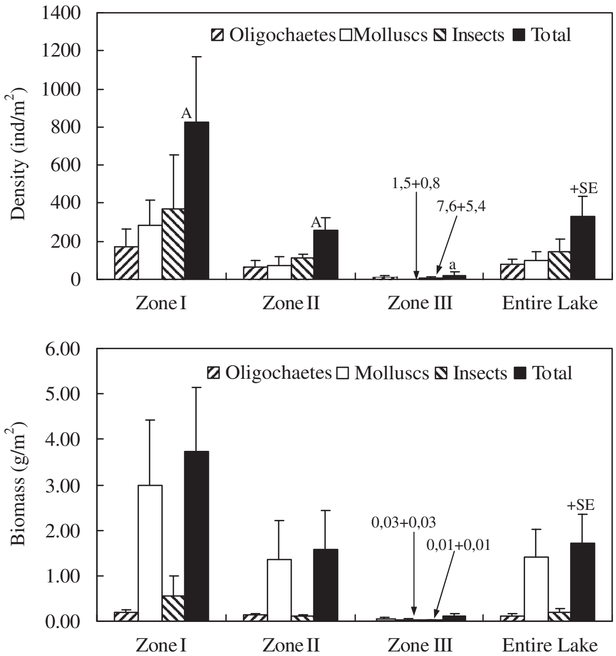

Fig. 2. Density and biomass (wet weight) of macrozoobenthos of different zones in Fuxian Lake (mean ± SE). Different letters above the bars indicate significant difference ($p < 0.01$) between zones within each taxonomic group.

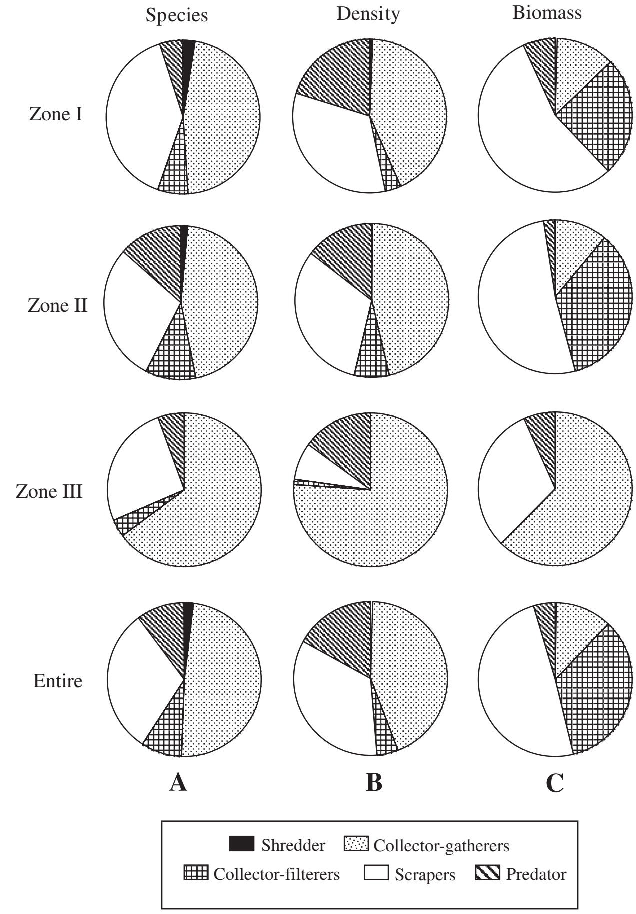

Fig. 3. Relative abundance of functional feeding groups of different zones in Fuxian Lake.

benthos in Fuxian Lake during investigating period was 5.6 g/m^2, which was equivalent to that of zooplankton in the lake (Qin, 2005). It implies that the ecological significance of macrozoobenthos in the lake should receive more attention. The calculation also showed that the total zoobenthic production in littoral zone (Zone I) was 12.0 g/m^2 and it gradually decreased to 3.0 g/m^2 in the profundal zone, so that most zoobenthic production is regarded to be contributed from the littoral.

Characteristics of the macrofauna and community structure

Although our research were derived from quantitative samples, up to 62 taxa were identified from the Fuxian Lake. Combining our result with other reports (Liu et al., 1980; Nanjing Institute of Geography and Limnology, 1990; Sket, 2000; Wang, 1988), nearly 100 zoobenthic species have been recorded from Fuxian Lake. About 40 taxa of molluscan and insects were not recorded in this study, this is mainly due to our samples were colleted from the offshore water but inshore water, so some molluscas were not capture, on the other hand, the diversity and population size of some taxa have been reducing, those were difficult to collect.

The macrofauna of Fuxian Lake is quiet characteristic. Although the numbers of species were the same in Zone I and Zone II, more molluscan species occurred in the former region. This finding may be ascribed to the fact that gastropods cannot adapt well to the deep and lower dissolved oxygen waters, but oligochaetes, especially the species of *Potamothrix* can adapt in profundal sediments. Only nine species were found in Zone III, and the mainly are oligochaetes. It is noteworthy that standing crops were higher in Zone I than those in Zone II, probably owing to the richness of allochthonous organic particles.

To apprehend its faunal relationship, Jaccard indexes (S_j) were calculated to compare faunal similarity between Fuxian Lake and other lakes (Table 3). It seems that the oligochaetes and chironomids in the lake are rather cosmopolitan, with resultant S_j ranging 0.1–0.2 for most lakes. The molluscs, especially bivalves, are more restricted in distribution. Their composition is close to that of Dianchi Lake in same region. In addition to this generality, it should be pointed out that Fuxian Lake is known to be rich in endemic species, especially the fishes, and this appears to apply to invertebrates as well. Examples are the new "baikaloid" amphipod *Fuxiana yangi* from deep water described by Sket (2000) and *P. scleropenis*, which has penial sheaths which are very different from those of its Holarctic allies

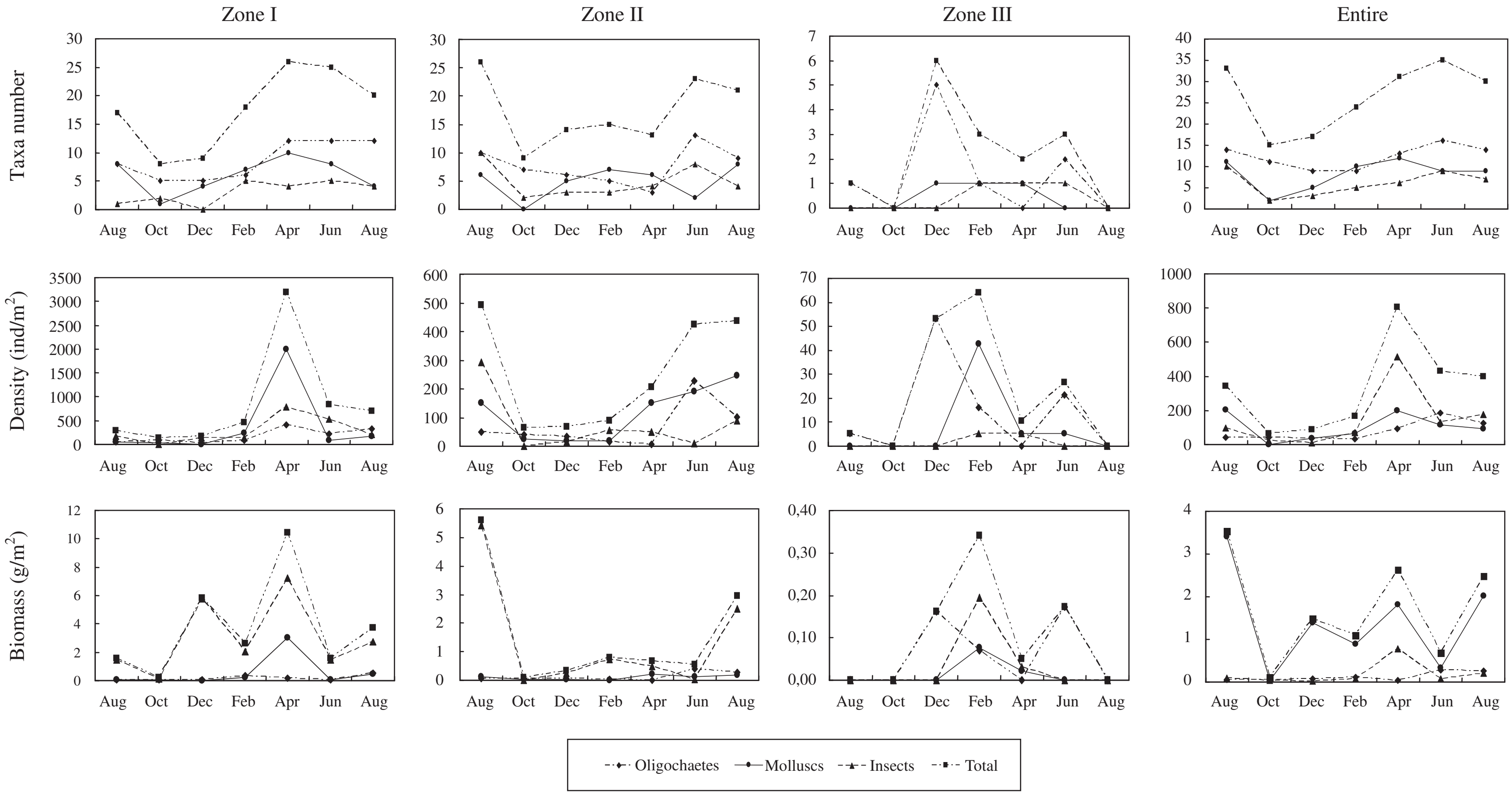

Fig. 4. Annual changes of taxa number, density (mean ± SE) and biomass (mean ± SE) (wet weight) of macrozoobenthos of different zones in Fuxian Lake.

Table 3. Comparison of environmental parameters, taxa number (share taxa in bracket), Jaccard similarity index (S_j) and abundance of macrozoobenthos among lakes

Water bodies	Location	Environmental parameters				Oligochaeta		Gastropoda		Bivalvia		Chironomidae		Density (ind/m^2)	Biomass (g/m^2)	References
		Area (km^2)	Mean depth (m)	TN (mg/L)	TP (mg/L)	SN[a]	S_j	SN[a]	S_j	SN[a]	S_j	SN[a]	S_j			
Fuxian Lake	N 24°17′–24°37′ and E 102°49′–102°57′	211	89	0.198±0.00	0.021±0.00	24	–	45	–	5	–	22	–	327±97	1.72±0.46	This study; Wang (1988); Nanjing Institute of Geography and Limnology, 1990
Dianchi Lake	N 24°40′–25°02′ and E 102°36′–102°47′	306	4.4	2.62	0.20	8 (4)	0.14	61 (16)	0.18	15 (3)	0.18	8 (3)	0.11	11089	58.95	Wang, 1985; Wang, 1988; Wang et al., 2002 Fang et al., 2004
Poyang Lake	N 28°24′–29°46′ and E 115°49′–116°46′	3283	6.1	0.99±0.05	0.06±0.01	23 (9)	0.24	44 (11)	0.14	65 (2)	0.03	13 (7)	0.25	596±116	146.7±22.9	Lin, 1962; Tchang and Li, 1965; Chen, 1988; Wu et al., 1994; Wu et al., 2000; Cui and Li, 2005
Longgan Lake	N 29°52′–30°05′ and E 115°19′–116°17′	252	3.8	1.008	0.082	13 (6)	0.18	3 (1)	0.02	1 (0)	0.0	11 (5)	0.18	136±24	21.7±9.3	Cui and Li, 2005
Lake Biwa	N 34°58′–35°31′ and E 135°52′–136°17′	370.3	41.2	0.33–0.39	0.008–0.018	41 (8)	0.14	38 (4)	0.05	17 (1)	0.05	16 (5)	0.15	–	–	Mori and Miura, 1980; Ohtaka and Nishino, 1999; Nishino and Watanabe, 2000
Lake Orta	N 45°45′ and E 8°23′	18.2	70.9	3.00±0.09	0.007±0.00	12 (5)	0.16	–	–	–	–	15 (7)	0.23	2017±540	3.98±1.06	Ambrosetti and Barbanti, 2001; Nocentini et al., 2001
Lake Baikal	N 51–54° and E 104–110°	31500	740	–	–	184 (5)	0.02	9 (0)	0.0	17 (0)	0.0	–	–	265–11165	–	Snimschikova and Akinshina, 1994; Martin et al., 1999; Kravtsova et al., 2004
Peipsi-Pihkva Lake	N 57°51′–59°01′ and E 27°30′–27°56′	3558	8.3	0.876	0.046	59 (12)	0.17	37 (0)	0.0	46 (0)	0.0	55 (11)	0.17	2617±213[b]	12.34±1.15[b]	Timm et al., 1996a, 1996b
Lake Superior	N 46°28′–48°58′ and W 84°37′–92°07′	82100	147	–	–	50 (9)	0.14	18 (2)	0.03	25 (0)	0.0	–	–	–	–	Grigorovich et al., 2003
Lake Huron	N 43°00′–46°2′ and W 79°50′–84°45′	59600	59	–	–	35 (5)	0.09	10 (2)	0.04	4 (0)	0.0	52 (8)	0.12	8344±2742	–	Nalepa et al., 2003; Barton, 2004

[a]Taxa (genus) number.
[b]Without large mollusk.

(Cui and Wang, 2005). The six unidentified oligochaetes in the present study are also peculiar. Very likely they will extend the list of endemic species from Fuxian Lake.

Standing stocks of zoobenthos in Fuxian Lake are much lower than those in other deep water bodies (Table 3). Although the density of zoobenthos in the lake is about equal to those in shallow Yangtze lakes, the biomass is 90% lower (Chen et al., 1980; Cui and Li, 2005; Liang and Liu, 1995). This is due to the different body size of molluscs which dominate zoobenthic wet biomass in Chinese lakes.

Seasonal changes

Significant seasonal changes were found in macrozoobenthic diversity and abundance in Fuxian Lake. The benthic fauna in the lake was the richest in summer, while those of Yangtze shallow lakes were richer in spring and autumn (Liang et al., 1995). In Fuxian Lake the density and biomass varied in different ways. The maximum density was observed in April, because of the increasing density of insects. Due to the fact that molluscs accounted for 82% in total biomass, the seasonal change of benthic biomass was governed by molluscs. This phenomenon is similar to that of Yangtze shallow lakes (Liang et al., 1995).

Conclusion remarks

Tectonic Fuxian Lake is an invaluable pool of species, especially those endemic forms (Yang and Chen, 1995). However, due to water deterioration and species invasion, the diversity of indigenous species in Fuxian Lake is decline from 25 to 18, and the yield of a famous endemic fish, *Anabarilius grahami* (Regan), were rapidly decreased from 193,500 kg in 1988 to 500 kg in 2003 (Qin, 2005). A program for lake conservation ought to be formulated, and more comprehensive studies should be carried out.

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